(12) UK Patent Application (19) GB (11) 2 315 072 (13) A

(43) Date of A Publication 21.01.1998

(21) Application No 9713927.3

(22) Date of Filing 01.07.1997

(30) Priority Data
(31) 96110805 (32) 04.07.1996 (33) EP

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(51) INT CL[6]
C09K 19/38 // C09K 19/46

(52) UK CL (Edition P)
C3P PDY PDZ
C3W W227
C4X X12
U1S S1346 S1387 S2285

(56) Documents Cited
GB 2305925 A GB 2299333 A GB 2298202 A
EP 0606940 A2 EP 0397263 A1 WO 97/23580 A1

(58) Field of Search
UK CL (Edition O) C3P PDA PDY PDZ
INT CL[6] C09K 19/38 19/46 19/52
ONLINE - WPI, CAS ONLINE

# (54) Circular UV polariser

(57) The invention relates to a circular UV polariser based on a polymerised mesogen being obtainable by curing by actinic radiation or by heat of a polymerisable composition which comprises the following components:

a) a liquid mesogenic component A composed of one or more achiral mesogenic compounds having at least one polymerisable end group optionally linked via a spacer group to the mesogenic core,

b) a component B composed of one or more chiral compounds in such an amount that the maximum wavelength of reflection ($\lambda_{max}$) of the composition is between 320 and 440 nm, and

c) a photoinitiator or thermal initiator component C.

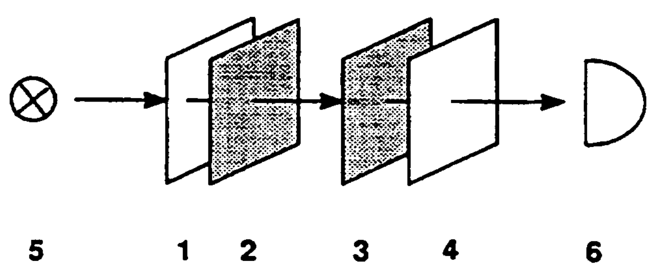


**Figure 1**

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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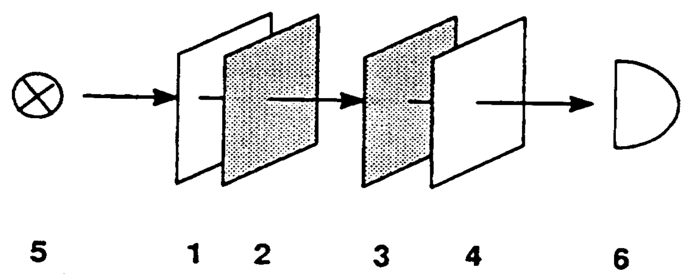



**Figure 1**

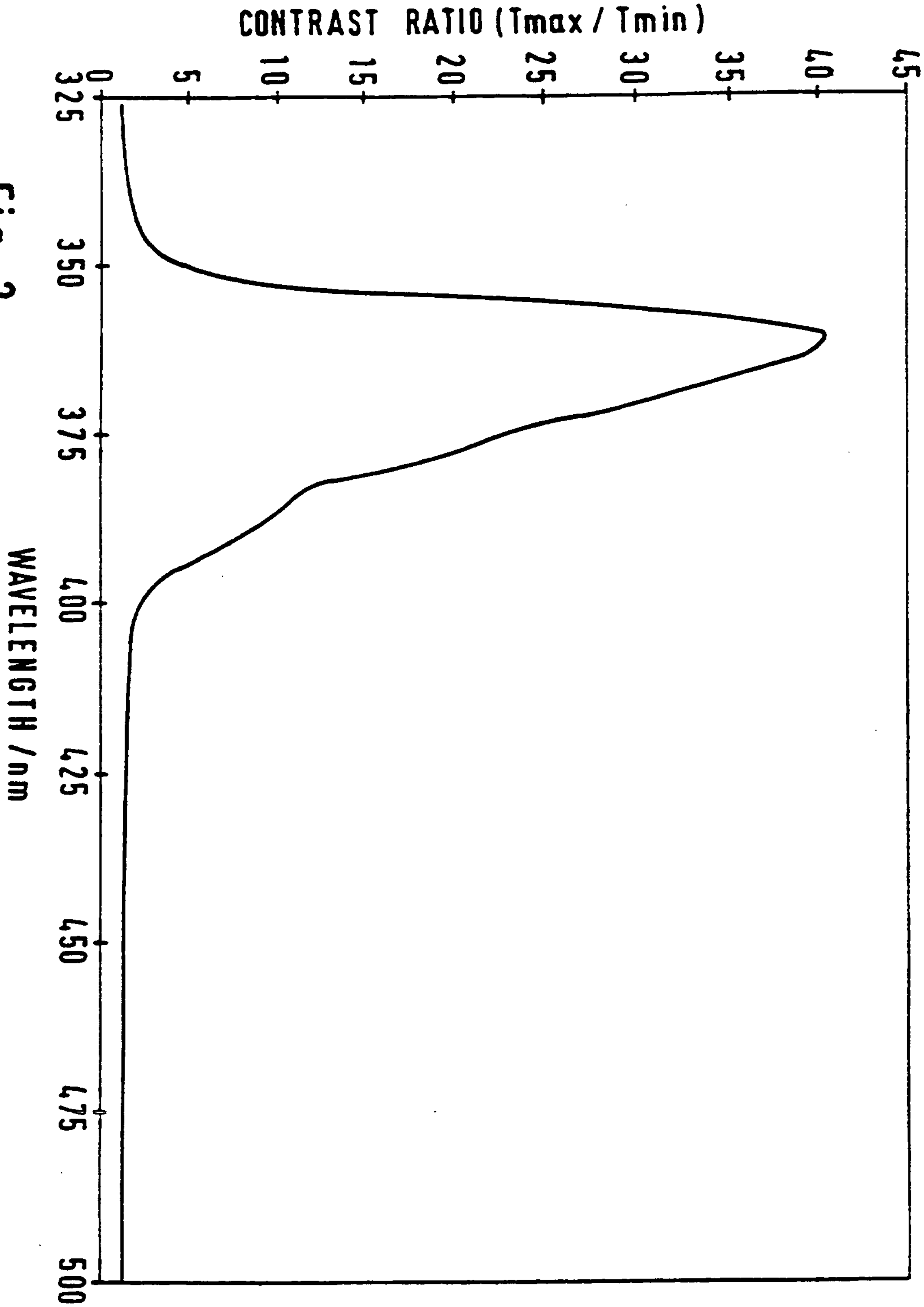

CONTRAST RATIO (Tmax / Tmin)
0
5
10
15
20
25
30
35
40
45
325
350
375
400
425
450
475
500
WAVELENGTH / nm

Fig. 2

## Circular UV Polariser

The invention relates to a circular UV polariser and to the use of such a circular UV polariser as spatial UV modulator.

There is a high demand for circular UV polarisers, since they allow to produce spatial UV modulators, e.g. for printer heads, photocopy machines, for creating UV patterns for UV curing of polymers, in particular in microelectronics. Moreover, circular UV polarisers allow to produce linearly polarised UV light if they are laminated to a suitable $\lambda/4$ plate with a retardation value of 0.25 times that of the wavelength of light that is transmitted as circularly polarised light.

Furthermore, they can be used for tuning the intensity of UV radiation for optical UV measurement equipments, in particular for optical work benches, optical computing or for CCD coupled devices. Another field of application are information displays, in particular colour displays, in advertising industry, public information displays including static or animated displays, based on the UV pattern monitored on a luminescent screen.

Conventional circular polarisers are used to polarise visible light. The European Patent application EP 0 606 940 discloses a liquid crystal polariser based on a cholesteric polymer material comprising a dye which absorbs light in the visible region.

The International patent application WO 93/10639 suggests a display apparatus in which the visible light emitted by UV stimulated phosphor elements is switched on or off with the aid of a liquid crystal TN device using crossed polarisers. However, it is more efficient to select each pixel directly by UV radiation that is turned on or off by a TN device having crossed UV polarizers being composed of a circular UV polarizer according to the invention a suitable $\lambda/4$ plate.

The present invention provides a circular UV sheet polariser based on polymerised mesogens, characterised in that said polymerised mesogens are obtainable by curing of a polymerisable composition using actinic radiation or heat the polymerisable composition comprising

a) a mesogenic component A comprising one or more achiral mesogenic compounds having at least one polymerisable end group optionally linked via a spacer group to the mesogenic core,

b) a mesogenic component B comprising one or more chiral mesogenic compounds which may be polymerizable compounds or non-polymerizable compounds, the polymerizable compounds having at least one polymerisable end group optionally linked via a spacer group to the mesogenic core, in such an amount that the maximum wavelength of reflection ($\lambda_{max}$) of the composition is between 320 and 440 nm, and

c) a photoinitiator component or a thermal initiator component C.

Preferably at least one of the components A and B is a liquid crystalline component.

In a first embodiment the component B comprises one or more polymerizable compounds. Preferably the component B is a liquid crystalline component.

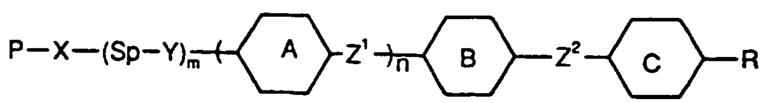
In a second embodiment the component B comprises at least one non-polymerizable compound.

Actinic radiation here does encompass UV radiation as well as light in the range of the visible spectrum. Compounds absorbing in this range of wavelengths and decomposing into reactive species initiating polymerisation of the precursor are simply called photoinitiators throughout the text.

Pr ferably the curing of the precursor i.e. the polymerizable composition is initiated by actinic radiation and not by heat. Most preferred is UV irradiation.

In a preferred embodiment the invention relates to:

a) a circular UV polariser, wherein said mesogenic component A comprises at least one compound of formula I

 I

in which

P is a polymerisable group,

X and Y are each independently -O-, -S-, -COO-, -OCO-, -OCOO-, -SCO-, -COS- or a single bond,

Sp is a linear spacer group with 1 to 16 carbon atoms,

the rings A, B and C denote each independently of each other and in case A is present two times also these independently of each other 1,4-phenylene being optionally substituted by one or two halogen atoms, cyano groups or $C_{1-6}$-alkyl groups, $C_{1-6}$-alkoxy groups or $C_{1-6}$-alkanoyl groups wherein one or more H atoms may be substituted by F or Cl, or denote 1,4-cyclohexylene,

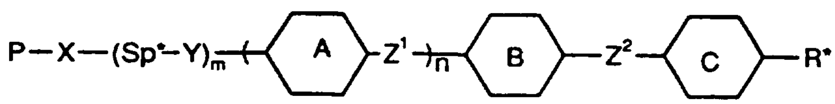
$Z^1$ and $Z^2$ are each independently of each other and in case $Z^1$ is present two times also these independently of each other $-CH_2CH_2-$, -COO-, -OCO-, $-OCH_2-$, $-CH_2O-$, -CH=CH-, -CH=CH-COO-, -OCO-CH=CH-, -C≡C- or a single bond,

R is an optionally fluorinated achiral alkyl, alkoxy or alkenyl group with 1 to 12 C atoms or denotes halogen or cyano or has one of the meanings given for P-X-(Sp-Y)$_m$-,

m is 0 or 1, and

n is 0, 1 or 2,

b) a circular UV polariser, wherein said component B comprises at least one compound of formula II:



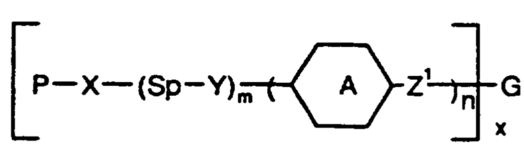
II

in which P, X, Y, $Z^1$, $Z^2$, n and m, the rings A, B and C have the meaning given for formula I directly above and

Sp* is an achiral or chiral spacer group with 1 to 16 carbon atoms, and

R* is an achiral or chiral alkyl, alkoxy or alkenyl group with 1 to 12 C atoms or denotes halogen or cyano or has one of the meanings given for P-X-Sp*-Y-,
with the proviso that at least one of the groups R* and Sp* is chiral,

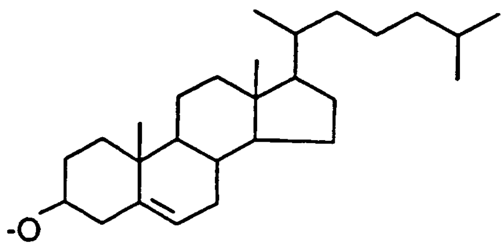
or alternatively component B comprises at least one mesogenic compound containing a chiral group of formula III:



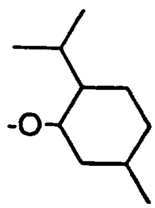
III

wherein P, X, Sp, Y, m, A, $Z^1$ and n have the meaning given for formula I directly above, x is 1 or 2 and G is a chiral structure element selected from the following groups:

for x = 1, a cholesteryl group,



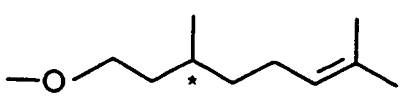
III1



III2

a terpenoid radical like , for example, menthol,

a group based on citronellol,



III3

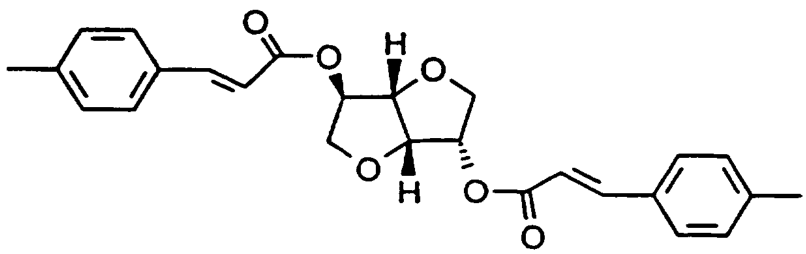
or an ethylenglycol derivative

$$-O-\overset{*}{\underset{}{C}}H(CH_3)CH_2OR^1$$

III4

wherein $R^1$ is an alkyl radical with 1 to 12 C atoms,

and for x = 2 a sugar derivative like, for example, a group based on 1,4:3,6-Dianhydro-D-sorbitol,

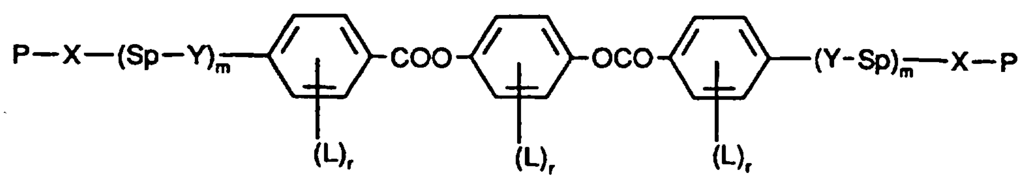


III5

c) a circular UV polariser, the film thickness of which is about 2 to 15 µm, in particular 3 to 10 µm.

In a particularly preferred embodiment, the component A is a composition of at least two compounds of formula I having two terminal polymerisable groups of formula P-X-Sp-Y-, in which the spacer groups have different chain length.

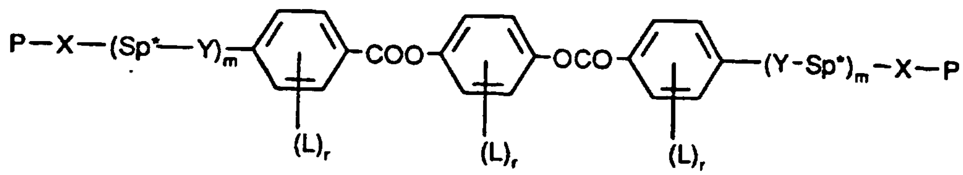
The achiral compounds of formula Ia are particularly preferred:




Ia

in which P, X, Sp, Y and m have the meaning given for formula I and L is halogen, CN or alkyl, alkoxy or alkanoyl each having up to 6 carbon atoms which is unsubstituted or mono- or polysubstituted by F or Cl, and r is 0, 1 or 2.

The chiral compounds of formula IIa are particularly preferred:



IIa

in which P, X, L, r and m have the meaning given and Sp* is a chiral spacer group.

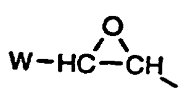
In the above mentioned formulae I, II, Ia and IIa the following definitions are preferred:

Sp is preferably a group of formula $-(CH_2)_s-$, in which s is an integer of 1 to 12,

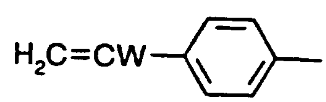
R* is preferably 2-methylbutyl or a group of formula P-X-Sp*-Y-, in which P, X and Y have the meaning given and Sp* is a chiral spacer group.

Sp* is preferably a group of formula $-(CH_2)_s-C^*H\ CH_3-(CH_2)_t-$ , in which s and t are each integers of 1 to 12 being different from each other.

P is preferably selected from $CH_2=CW-$, $CH_3-CH=CW-$ and the structural elements 1 and 2



1,



2

in which W denotes H, Cl or $CH_3$.

Particularly preferred polymerisable groups P-X are selected from acrylate, methacrylate, vinyl, vinyloxy, propenyl, propenyloxy, epoxy

and styryl, very particular preferably from acrylate, methacrylate, propenyloxy and epoxy.

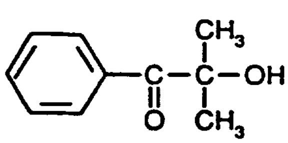
L is preferably F, Cl, CN, $NO_2$, $CH_3$, $C_2H_5$, $OCH_3$, $OC_2H_5$, $COCH_3$, $COC_2H_5$, $CF_3$ and $OCF_3$, in particular F, $CH_3$, $OCH_3$ and $COCH_3$.

The polymerization of the precursor can be initiated by the use of a thermal initiator as initiating component C. Such thermal starters are widely known.

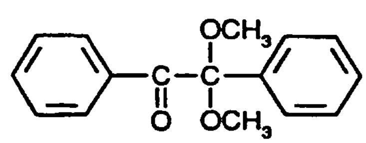
For the polymerization initiating component C in general any photoinitiator can be used that decomposes when exposed to actinic radiation. These photoinitiators are commercially available in a wide variety.

For the instant invention it is rather important that in case a photoinitiator is used as initiating component C it is properly selected. It preferably should absorb light in the visible spectral range to limit any possible interference with the function of the chiral systems as UV polarizers. Such undesired effects might e.g. result from the cholesteric film reflecting just that part of UV radiation which would be required for the photoinitiating step if the photoinitiator is not properly selected. On the other hand residual photoinitiator might lead to undesired absorption of the UV radiation in the final operation of the system.

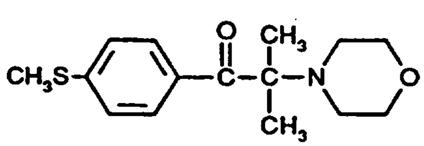
Preferably the photoinitiator component C comprises at least one compound selected from the following group of formulae IVa to IVd



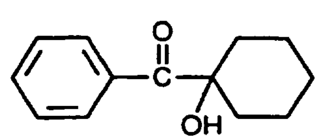
IVa,



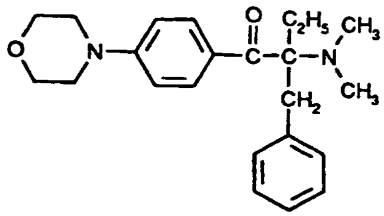
IVb,



IVc,



IVd and



IVe.

In addition to photoinitiators or thermal initiators the polymerisable composition can also comprise one or more other suitable components such as, for example, catalysts, stabilizers, co-reacting monomers, surface-active compounds or sensitizers such as, for example ITX (Isopropyl thioxanthone) to aid curing.

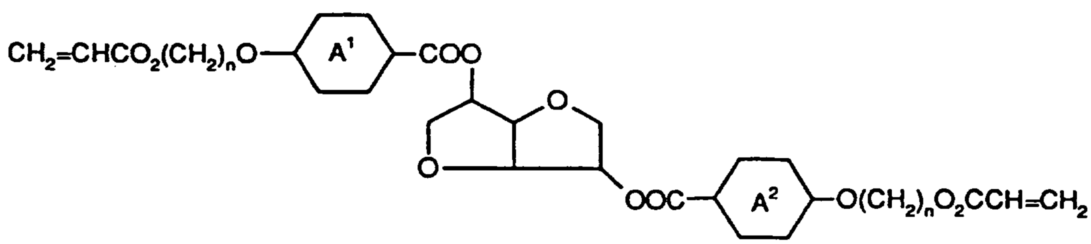
It is alternatively possible to add, for example, a quantity of up to 20% by weight of a nonpolymerisable liquid-crystalline material to adapt the optical properties of the polymer.

It is also possible to add up to 20% of a non mesogenic compound with two or more polymerizable functional groups to increase cross-linking of the polymers. Typical examples for difunctional non mesogenic monomers are alkyldiacrylates or alkyldimethacrylates with alkyl groups of 1 to 20 C atoms. Typical examples for non mesogenic monomers with more than two polymerizable groups are trimethylpropanetrimethacrylate or pentaerythritoltetraacrylate.

Besides the reactive liquid crystals described above as the constituents of component A of the polymer precursor it is obviously also possible according to the instant invention to use chiral, reactive, non-liquid crystalline compounds. These are well known by the expert.

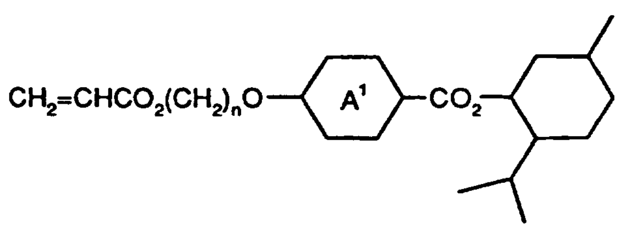
The helical twisting power of chiral substances is given in $\mu m^{-1}$ at 20 °C throughout the text unless explicitly stated otherwise.

The chiral component used, preferably does not absorb UV radiation. Especially compounds which do not absorb in the range of long UV wavelengths, namely in the region of 360 to 400 nm are preferred. Obviously compounds which do not absorb at all in this range would be preferred. As, however, this ideal condition is hardly met, compounds with only small absorption in this region are preferred. Further compounds with a high helical twisting power (HTP) are preferred, as their influence on the properties of the mixture especially the mesogenic properties, e.g. the clearing point, is rather small. Examples of such chiral, reactive, non liquid crystalline compounds are the following compounds which are sorbitols and menthols of formulae V and VI:




V

and

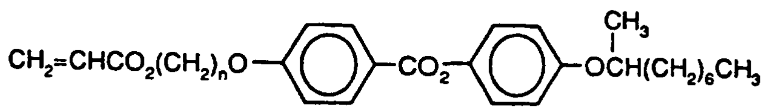



VI

wherein $A^1$ and $A^2$ are independently of each other 1,4-phenylene and trans 1,4-cyclohexylene and wherein n is 1 to 8.

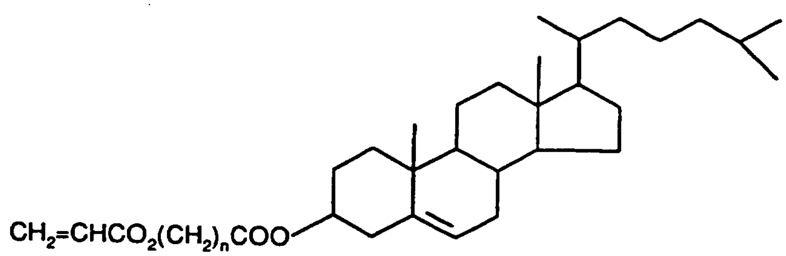
The HTP of these sorbitols is about 60-70. The preferred benzoic acid for the sorbitols is cyclohexanoic acid. Also for the menthol preferably a cyclohexyl ring is used as $A^1$. The HTP of menthols is about 20.

Other suitable chiral compounds are containing groups like 2-octanol (and 2-methyl butyl) but these generally are of lower HTP.

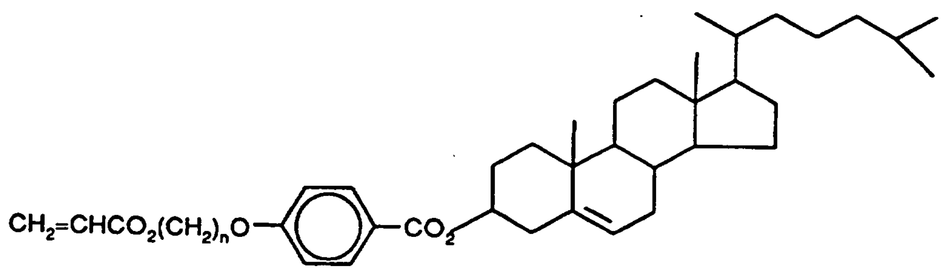


VII

Also cholesterol and steroids in general can be used e.g. in compounds such as:



VIII



IX

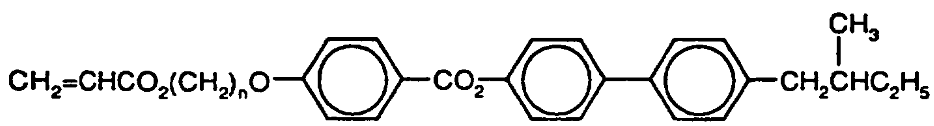
n = 1 to 8

These compounds VII to IX typically have HTP values of about 5-10.

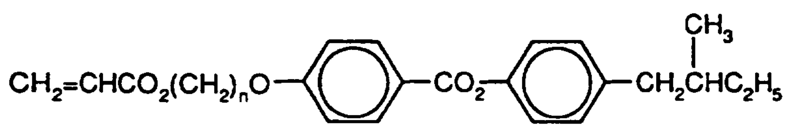
In addition to or alternatively to the chiral, reactive, non-liquid crystalline compounds also chiral, non-reactive, non-liquid crystalline compounds may be used, however, they are used preferable together with the former compounds or with the chiral reactive liquid crystals as described above.

It is also possible to add, in addition to or alternatively to these compounds, chiral, non-reactive liquid crystalline compounds, like e.g. commercially available chiral dopants, to the polymerisable composition.

Examples of compounds which can be used as chiral, reactive, liquid crystals according to the instant application are compounds of formulae X and XI



X



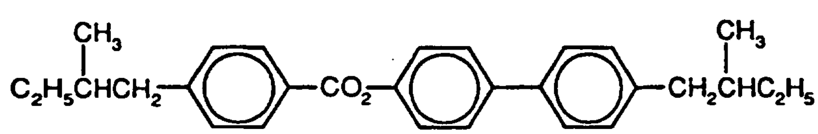
XI

n being 1 to 8.

Also the citronellol based compounds can be used. Of course these materials are not ideal for all applications as they are containing somewhat conjugated structures and do absorb in the near UV to some extent.

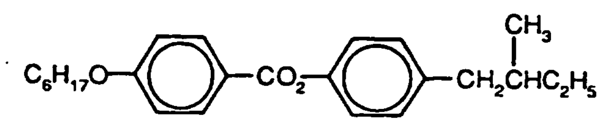
Compounds containing cyclohexyl rings instead of phenyl rings are preferred for most application.

Typical examples of chiral, non-reactive, liquid crystals which can be used are the chiral dopants R-2011, CE2 and CE all available from Merck KGaA, Darmstadt.



XII

CE2

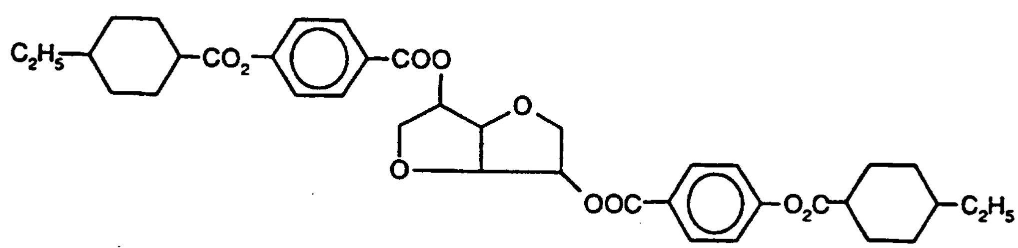


XIII

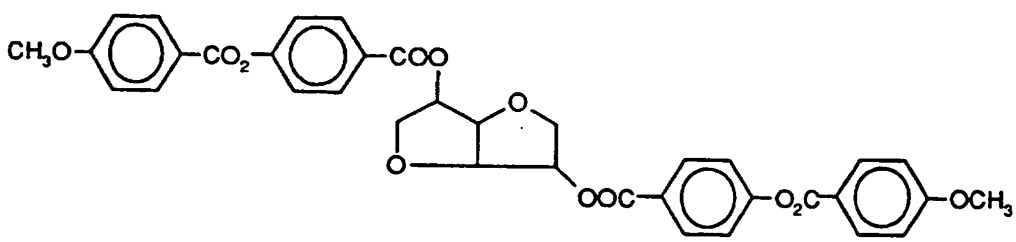
CE compounds

R-2011 has a HTP of about 11 µm$^{-1}$, CE2 has a HTP of about 10 µm$^{-1}$ and CE compounds of about 5 to 7.

Examples for chiral, non-reactive, non-liquid crystals which are mesogenic compounds are again sorbitols and menthols. Also compounds such as cholesterol esters, R-1011 available from Merck KGaA etc. can be used as co-dopants. Of course the HTP of these compounds has be high so that the matrial is not present in high concentrations otherwise it may phase separate when the polymer is formed. Examples are:



XIV



XV

In a preferred embodiment, the circular UV polariser is based on polymerised mesogens obtained by UV curing of a polymerisable composition comprising

a) 15 to 95 %, preferably 20 to 85 %, in particular 25 to 80 % by weight of mesogenic component A

b) 5 to 85 %, preferably 10 to 75 %, in particular 15 to 70 % by weight of mesogenic component B, and

c) 0.01 to 10, preferably 0.1 to 5 % by weight of photoinitiator or thermal initiator component C.

The ratio of components A and B determines the reflection maximum of the composition and depends on the pitch of component B. Within the preferred ranges given above the ratio of component A to component B should therefore be chosen such that the reflection maximum of the composition is between 320 and 440 nm.

On the other hand, the use of monoreactive and direactive polymerisable compounds of group A and B (i.e. compounds having one or two polymerisable groups P respectively) determines the optical properties of the circular polariser, in particular their temperature dependence and the mechanical stability of the polariser film. It is therefore sometimes useful to vary the crosslinking by using different ratios of mono- and direactive compounds of formula I and/or II.

In a preferred embodiment the polymerisable composition comprises at least one monoreactive and at least one direactive compound of formula I and/or II. In another preferred embodiment the polymerisable composition comprises only direactive compounds of formula I and/or II. In another preferred embodiment the polymerisable composition comprises at least two monoreactive compounds of formula I and/or II.

The inventive circular UV polariser, when irradiated with UV light of a wavelength in the range of the maximum reflection wavelength of the polymerised mesogens, reflects half of the intensity of the incident light as left-handed or right-handed circularly polarised. The other half is transmitted as circularly polarised light of the opposite handedness.

In a preferred embodiment the circular UV polariser according to the present invention is laminated to a quarter wave foil having a retardation value of 0.25 times of the wavelength of light transmitted by the circular polariser to provide linear polarised light. Contrast ratios of about 40:1 can be obtained. These can be further increased by using a UV linear polariser obtainable by UV curing of a polymerisable composition which comprises 60 to 99 % by weight of a liquid crystalline component composed of one or more achiral mesogenic compounds having at least one polymerisable end group optionally linked via a spacer to the mesogenic core, 0.1 to 30 % by weight of a dichroic dye component that absorbs light in the UV region, and 0.01 to 10 % by weight of a photoinitiator.

The additional linear polarizer as a rule exhibits a polarisation contrast ratio of about 1 : 10. The combination of these polarisers, therefore, yields a contrast ratio of 400 : 1. This technique has the advantage that the linear polariser does not have to absorb as much UV light, thus preventing overheating and increasing its life time.

In another preferred embodiment the UV polariser according to the invention is combined with a UV lamp and a reflector that re-reflects the circularly polarised, which was reflected from the inventive circular UV polariser, with a change of its handedness. This re-reflected light will then be transmitted by the circular UV polariser. In this way most of the UV light is converted to circularly polarised of a single handedness or, if a $\lambda/4$ plate is used, to linearly polarised UV light.

In another preferred embodiment the UV lamp is combined with a diffusor that depolarises the light coming from the reflector. This light is then again directed onto the circular UV polariser and split up in a reflected and a transmitted portion. In this way, too, most of the UV light is converted to circularly polarised of a single handedness or, if a $\lambda/4$ plate is used, to linearly polarised UV light.

Embodiments of the present invention will now be described, by way of example only.

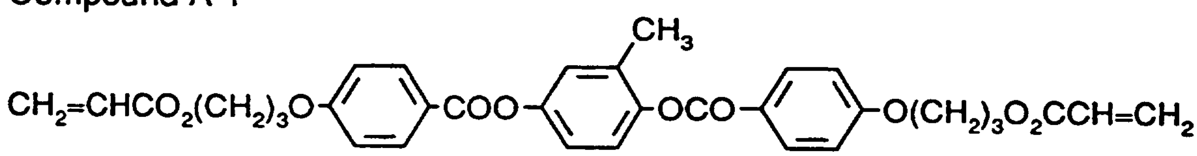
Without further elaboration, it is believed that one skilled in the art can, using the preceding description, utilize the present invention to its fullest extent. The preferred specific embodiments are, therefore, to be construed as merely illustrative, and not limitative of the disclosure in any way whatsoever.

The following abbreviations are used:

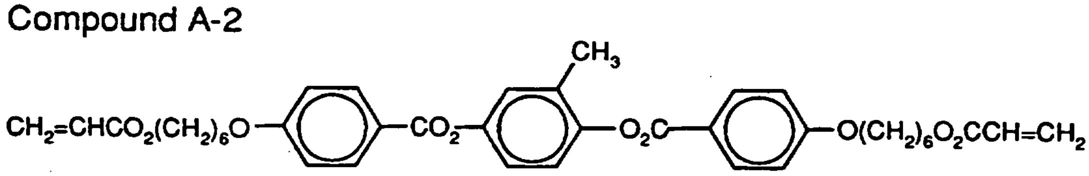
$\lambda$ = wavelength of actinic irradiation
I = lamp power

The following acronyms are used to define the different components of the liquid crystalline composition according to the invention:

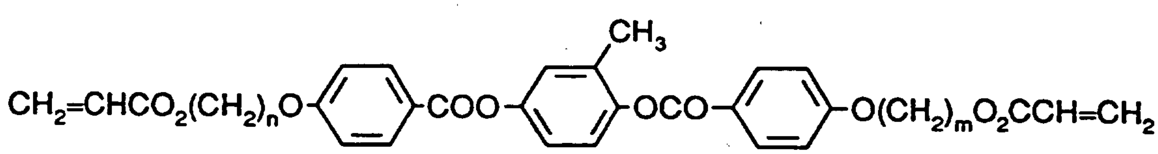
Compound A-1



Compound A-2

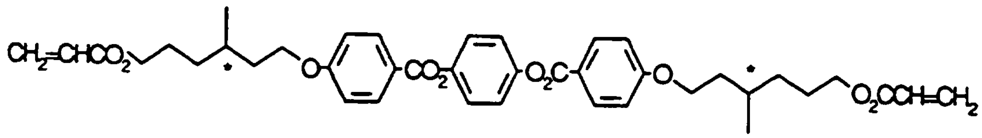


Mixture M-1 of compounds A-1 to A-4

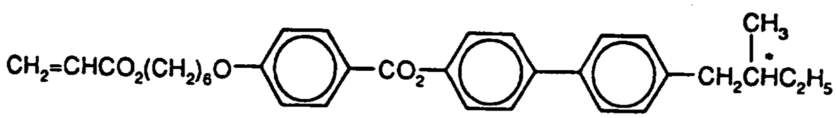


A-1: n = m = 3 (25 %) ; A-2: n = m = 6 (25 %) ;
A-3: n = 3, m = 6 (25 %) and A-4: n = 6, m = 3 (25 %).

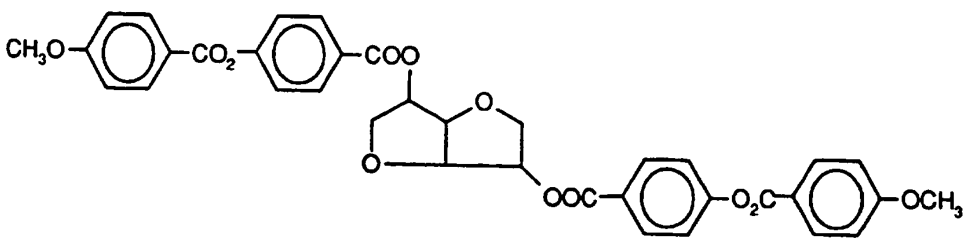
Compound B-1



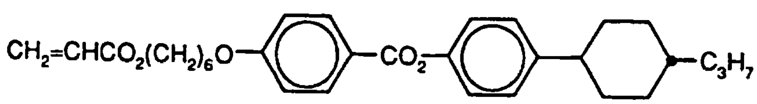
Compound C-1



Compound D-1



Compound E-1



Irgacure 184 and Irgacure 651 are commercially available photoinitiators from Ciba Geigy AG.

R-1011 is a liquid crystalline chiral dopant with a polar fluorinated terminal group available from Merck KGaA.

Example 1

A polymerisable composition consisting of:

| Acronym | wt. % |
|---|---|
| B-1 | 53.00 |
| A-1 | 46.00 |
| Irgacure 184 | 1.00 |

is sandwiched between two microscope slides and exposed to UV light ($\lambda$ = 370 - 390 nm, I = 6 mW/cm$^2$) for five minutes at 75 °C. The maximum wavelength of reflection of the resulting film is at 370 nm.

Example 2

A polymerisable composition consisting of:

| Acronym | wt. % |
|---|---|
| B-1 | 49.50 |
| A-1 | 49.50 |
| Irgacure 651 | 1.00 |

is sandwiched between two microscope slides and exposed to UV light ($\lambda$ = 370 - 390 nm, I = 6 mW/cm$^2$) for five minutes at 75 °C.

The maximum wavelength of reflection of the resulting film is at 404 nm.

Example 3

As depicted in Figure 1, two samples of the cholesteric film of example 1 (**1** and **4** ) are combined each with a quarter wave foil whose retardation is 90 nm. The first quarter wave foil **2** has a first axis at 0 °

to the vertical, whereas the second quarter wave foil **3** has a first axis at 0 ° and 90 ° to the vertical. These two combinations of films are placed in a spectrophotometer comprising a source of unpolarised light **5** and a detector for the UV and visible range of wavelengths **6**. The films are arranged such that the polarised light transmitted by the first combination of films **1** and **2** is incident upon the second combination of films **3** and **4**.

The contrast ratio for the combination of films **1, 2, 3** and **4** according to the setup of Figure 1 in dependence of the wavelength of the incident light from the light source **5** is depicted in Figure 2. As can be seen, the maximum contrast ratio is 40:1 in the UV region at a wavelength of about 360 nm.

Example 4

A polymerisable composition using a reactive liquid crystal (C-1) and a chiral, non-reactive, non-liquid crystal (D-1) was used consisting of:

| Acronym | wt. % |
|---|---|
| C-1 | 65.00 |
| A-2 | 32.00 |
| D-1 | 2.00 |
| Irgacure 184 | 1.00 |

This mixture was cured as a thin (5 μm) film using a Dr. Hönle metal halogen lamp for 20 seconds between two glass substrates to give a cholesteric polymer film with a maximum reflectance wavelength of 380 nm.

Example 5

Uses chiral non-reactive, non-liquid crystal dopants (D-1 and R-1011) in a nematic mixture composed of mono (E-1) and diacrylates (A-2)

| Acronym | wt. % |
|---|---|
| E-1 | 10.00 |
| A-2 | 81.20 |
| D-1 | 3.90 |
| R-1011 | 3.90 |
| Irgacure 651 | 1.00 |

This mixture was cured as in Example 4 to give a film with a maximum reflection wavelength of 385 nm.

## Claims

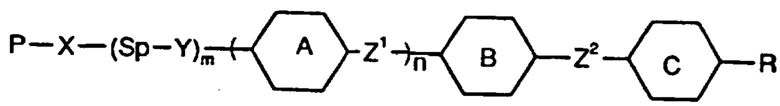
1. A liquid crystal circular UV sheet polariser based on polymerised mesogens characterized in that said polymerised mesogens are obtainable by curing by actinic radiation or by heat of a polymerisable composition comprising:

   a) a mesogenic component A comprising one or more achiral mesogenic compounds having at least one polymerisable end group optionally linked via a spacer group to the mesogenic core,

   b) a component B comprising one or more chiral compounds in such an amount that the maximum wavelength of reflection ($\lambda_{max}$) of the composition is between 320 and 440 nm, and

   c) a photoinitiator or thermal initiator component C.

2. A circular UV polariser according to claim 1, characterised in that component A comprises at least one compound of formula I:



I

in which

| | |
|---|---|
| P | is a polymerisable group, |
| X and Y | are each independently -O-, -S-, -COO-, -OCO-, -OCOO-, -SCO-, -COS- or a single bond, |
| Sp | is a linear spacer group with 1 to 16 carbon atoms, |

A, B and C denote each independently 1,4-phenylene being optionally substituted by one or two halogen atoms, cyano groups or $C_{1-6}$-alkyl groups, $C_{1-6}$-alkoxy groups or $C_{1-6}$-alkanoyl groups wherein one or more H atoms may be substituted by F or Cl, or denote 1,4-cyclohexylene,

$Z^1$ and $Z^2$ are each independently $-CH_2CH_2-$, -COO-, -OCO-, $-OCH_2-$, $-CH_2O-$, -CH=CH-, -CH=CH-COO-, -OCO-CH=CH-, -C≡C- or a single bond,

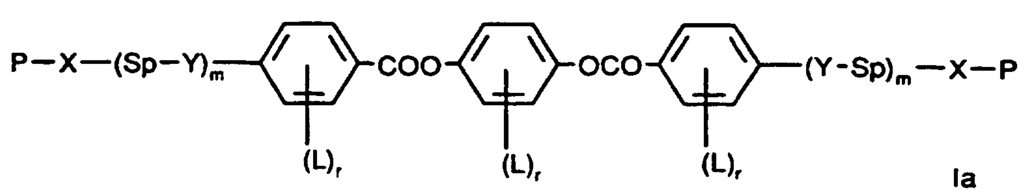
R is an optionally fluorinated achiral alkyl, alkoxy or alkenyl group with 1 to 12 C atoms or denotes halogen or cyano or has one of the meanings given for $P-X-(Sp-Y)_m-$,

m is 0 or 1, and

n is 0, 1 or 2,

3. A circular UV polariser according to claim 2, characterised in that component A comprises a composition of at least two compounds of formula I having two terminal polymerisable groups of formula P-X-Sp-Y-, wherein the spacer groups have different chain length.

4. A circular UV polariser according to claim 2 or 3, characterised in that component A comprises at least one compound of formula I a



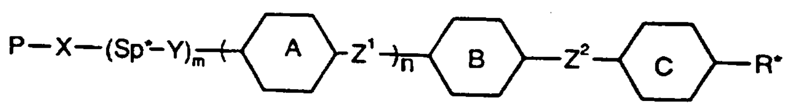

Ia

in which

P, X, Sp, Y and m have the meaning given for formula I and

L is halogen, CN or alkyl, alkoxy or alkanoyl each having up to 6 carbon atoms which is unsubstituted or mono- or polysubstituted by F or Cl, and r is 0, 1 or 2.

5. A circular UV polariser according to any of the claims 1 to 4, characterised in that, said component B comprises at least one compound of formula II:



II

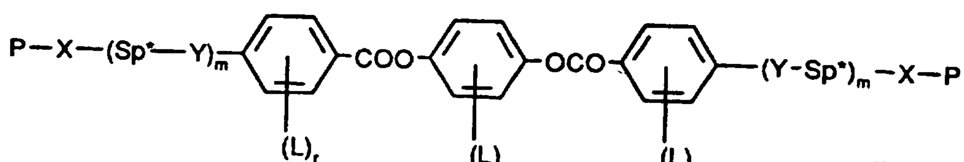
in which P, X, Y, $Z^1$, $Z^2$, n and m, the rings A, B and C have the meaning given and

$Sp^*$ is an achiral or chiral spacer group with 1 to 16 carbon aoms, and

$R^*$ is an achiral or chiral alkyl, alkoxy or alkenyl group with 1 to 12 C atoms or denotes halogen or cyano or has one of the meanings given for P-X-$(Sp^*)_m$-Y-,

with the proviso that at least on of the groups $R^*$ and $Sp^*$ is chiral.

6. A circular UV polariser according to any of the claims 1 to 5, characterised in that component B comprises a composition of at least one compound of formula IIa



IIa

in which P, X, L, r and m have the meaning given and Sp* is a chiral spacer group.

7. A circular UV polariser according to any of the claims 1 to 6, characterised in that said polymerised mesogens are obtained by UV curing of a polymerisable composition comprising

   a) 15 to 95 % by weight of liquid crystalline component A,

   b) 5 to 85 % by weight of liquid crystalline component B, and

   c) 0.01 to 10, preferably 0.1 to 5 % by weight of photoinitiator component C.

8. A circular UV polariser according to any of the claims 1 to 7, characterised in that the film thickness of said polariser is about 2 to 15 μm, in particular 3 to 10 μm.

9. Use of a circular UV polariser according to any of the claims 1 to 8 as spatial circular UV modulator.

10. Means for producing linearly polarised UV light comprising

    a) an UV light emitting source,

    b) a circular UV polariser according to claims 1 to 8,

    c) a λ/4 plate with a retardation value of approximately 0.25 times of the wavelength of light that is transmitted by said circular polariser,

    d) a reflector which re-reflects the circular polarised UV light reflected by said circular UV polariser under inversion of its handedness

e) optionally a diffusor, and

f) optionally a linear UV polariser.

11. Means for producing linearly polarised UV light according to claim 10, characterised in that the linear UV polariser is obtainable by UV curing of a polymerisable composition which comprises 60 to 99 % by weight of a liquid crystalline component composed of one or more achiral mesogenic compounds having at least one polymerisable end group optionally linked via a spacer to the mesogenic core, 0.1 to 30 % by weight of a dichroic component that absorbs light in the UV region, and 0.01 to 10 % by weight of a photoinitiator or a thermal initiator.

| | | | |
|---|---|---|---|
| **Application No:** | GB 9713927.3 | **Examiner:** | Martin Price |
| **Claims searched:** | 1-11 | **Date of search:** | 30 October 1997 |

## Patents Act 1977
## Search Report under Section 17

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): C3P - PDA, PDY, PDZ

Int Cl (Ed.6): C09K 19/38, 19/46, 19/52

Other: Online - WPI, CAS Online

**Documents considered to be relevant:**

| Category | Identity of document and relevant passage | | Relevant to claims |
|---|---|---|---|
| A | GB 2 305 925 A | (Merck) - example 2 | |
| X, P | GB 2 299 333 A | (Merck) - examples 7-10 and claim 9 | 1-8 |
| A | GB 2 298 202 A | (Merck) - example 3 | |
| X | EP 0 606 940 A2 | (Philips) - whole document | 1-11 |
| X | EP 0 397 263 A1 | (Philips) - example on pages 8-9 | 1-8 |
| X | WO 97/23580 A1 | (Philips) - pages 8 and 9; figures | 1-11 |

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